

9-05 DRAINAGE STRUCTURES, CULVERTS, AND CONDUITS**9-05.0 Acceptance by Manufacturer's Certification**

Certain drainage materials may be accepted by the Engineer based on a modified acceptance procedure when materials are furnished from the manufacturer's list in the Qualified Products List (QPL) or by a Manufacturer's Certificate of Compliance. The modified acceptance procedure is defined in the QPL for each material. These materials are as follows:

- Metal drain and under drain pipe;
- PVC and corrugated polyethylene drain pipe and under drain pipe;
- Metal culvert and storm sewer pipe and pipe arch;
- Metal culvert end sections;
- Corrugated metal structural plate pipe, pipe arch, and under passes; and
- Ductile iron pipe.
- Corrugated polyethylene culvert and storm sewer pipe up to and including 60-inch diameter.
- Profile wall PVC culvert and storm sewer pipe up to and including 48-inch diameter.

9-05.1 Drain Pipe**9-05.1(1) Concrete Drain Pipe**

Concrete drain pipe shall meet the requirements of ASTM C 118, heavy duty drainage pipe.

9-05.1(2) Zinc Coated (Galvanized) or Aluminum Coated (Aluminized) Corrugated Iron or Steel Drain Pipe

Zinc coated (galvanized) or aluminum coated (aluminized Type 2) corrugated iron or steel drain pipe shall meet the requirements of AASHTO M 36. The steel sheet thickness shall be 0.064-inch for 6-inch diameter and larger drain pipe. Zinc coated steel shall meet the material requirements of AASHTO M 218 (ASTM A929). Aluminum coated steel shall meet the material requirements of AASHTO M-274 (ASTM A929).

9-05.1(2)A Coupling Bands

Coupling bands for zinc coated (galvanized) or aluminum coated (aluminized) corrugated iron or steel drain pipe shall meet the requirements of coupling bands for Type I pipe of AASHTO M 36, except that bands using projections (dimples) shall not be permitted. The bands shall be fabricated of the same material as the pipe, and with the same metallic protective treatment as the pipe.

Acceptable coupling bands are the two piece helically corrugated band with nonreformed ends and integrally formed flanges and those bands meeting the requirements of Section 9-05.4(7).

9-05.1(3) Corrugated Aluminum Alloy Drain Pipe

Corrugated aluminum alloy drain pipe shall meet the requirements of AASHTO M 196, without perforations.

9-05.1(3)A Coupling Bands

Coupling bands for corrugated aluminum alloy drain pipe shall meet the requirements of coupling bands for Type I pipe of AASHTO M 196, except that bands using projections (dimples) shall not be permitted. The bands shall be fabricated of the same material as the pipe.

Acceptable coupling bands are the two piece helically corrugated band with nonreformed ends and integrally formed flanges and those bands meeting the requirements of Section 9-05.5(5).

9-05.1(4) Vacant**9-05.1(5) PVC Drain Pipe, Couplings and Fittings**

PVC drain pipe, couplings, and fittings shall meet the requirements of AASHTO M 278. The maximum size pipe shall be 8-inches in diameter.

9-05.1(6) Corrugated Polyethylene Drain Pipe, Couplings and Fittings (up to 10-inch)

Corrugated polyethylene drain pipe, couplings, and fittings shall meet the requirements of AASHTO M 252 type C (corrugated both inside and outside) or type S (corrugated outer wall and smooth inner liner). The maximum size pipe shall be 10 inches in diameter.

9-05.1(7) Corrugated Polyethylene Drain Pipe, Couplings and Fittings (12-inch through 60-inch)

Corrugated polyethylene drain pipe, couplings, and fittings 12-inch through 60-inch -diameter maximum, shall meet the minimum requirements of AASHTO M 294 Type S or 12-inch through 24 inch diameter maximum shall meet the minimum requirements of AASHTO M 294 Type C.

9-05.2 Underdrain Pipe**9-05.2(1) Vacant****9-05.2(2) Perforated Concrete Underdrain Pipe**

Perforated concrete underdrain pipe shall meet the requirements of AASHTO M 175, Type I, except the perforations shall be approximately ½-inch in diameter. Strength requirements shall be as shown in Table I of AASHTO M 86.

9-05.2(3) Vacant**9-05.2(4) Zinc Coated (Galvanized) or Aluminum Coated (Aluminized) Corrugated Iron or Steel Underdrain Pipe**

Zinc coated (galvanized) or aluminum coated (aluminized type 2) corrugated iron or steel underdrain pipe shall meet the fabrication requirements of AASHTO M 36, except that perforations required in Class I, II, and III pipe may be located anywhere on the tangent of the corrugations provided the other perforation spacing requirements remain as specified. Zinc coated steel shall meet the material requirements of AASHTO M 218 (ASTM A929). Aluminum coated steel shall meet the material requirements of AASHTO M-274 (ASTM A929).

The pipe may conform to any one of the Type III pipes specified in AASHTO M 36, and perforations in Class I, II, and III pipe may be drilled or punched. The sheet thickness shall be 0.064-inch for 6-inch and larger diameter underdrain pipe.

9-05.2(4)A Coupling Bands

Coupling bands for zinc coated (galvanized) or aluminum coated (aluminized) corrugated iron or steel underdrain pipe shall meet the requirements of coupling bands for Type III pipe of AASHTO M 36. The bands shall be fabricated of the same material as the pipe and with the same metallic protective treatment as the pipe, if metallic bands are used.

Acceptable coupling bands are the two piece helically corrugated band with nonreformed ends and integrally formed flanges, universal bands (dimple bands), a smooth sleeve type coupler, and those bands meeting the requirements of Section 9-05.4(7). Smooth sleeve type couplers may be either plastic or steel suitable for holding the pipe firmly in alignment without the use of sealing compound or gaskets.

9-05.2(5) Perforated Corrugated Aluminum Alloy Underdrain Pipe

Perforated corrugated aluminum alloy underdrain pipe shall meet the requirements of AASHTO M 196, except that the perforations may be located anywhere on the tangent of the corrugations providing the other perforation spacing requirements remain as specified.

9-05.2(5)A Coupling Bands

Coupling bands for corrugated aluminum alloy underdrain pipe shall meet the requirements of coupling bands for Type III pipe of AASHTO M 196. The bands shall be fabricated of the same material of the pipe, if metallic bands are used.

Acceptable coupling bands are the two piece helically corrugated band with nonreformed ends and integrally formed flanges, universal bands (dimple bands), a smooth sleeve type coupler, and those bands meeting the requirements of Section 9-05.5(5). Smooth sleeve type couplers may be either plastic or aluminum alloy suitable for holding the pipe firmly in alignment without the use of sealing compound or gaskets.

9-05.2(6) Perforated PVC Underdrain Pipe

Perforated PVC underdrain pipe shall meet the requirements of AASHTO M 278. The maximum size pipe shall be 8-inches in diameter.

9-05.2(7) Perforated Corrugated Polyethylene Underdrain Pipe (Up to 10-24 inch)

Perforated corrugated polyethylene underdrain pipe shall meet the requirements of AASHTO M252, Type CP or Type SP. Type CP shall be Type C pipe with Class 2 perforations and Type SP shall be Type S pipe with either Class 1 or Class 2 perforations. Additionally, Class 2 perforations shall be uniformly spaced along the length and circumference of the pipe. The maximum size pipe shall be 10-inch diameter.

9-05.2(8) Perforated Corrugated Polyethylene Underdrain Pipe (12-inch 35 through 60-inch)

Perforated corrugated polyethylene underdrain pipe, 12-inch through 60-inch diameter maximum, shall meet the requirements of AASHTO M 294 Type CP or Type SP. Type CP shall be Type C pipe with Class 2 perforations and Type SP shall be Type S pipe with either Class 1 or Class 2 perforations. Additionally, Class 2 perforations shall be uniformly spaced along the length and circumference of the pipe.

9-05.3 Concrete Culvert Pipe**9-05.3(1) Plain Concrete Culvert Pipe**

Plain concrete culvert pipe shall be round and shall conform to the requirements of AASHTO M 86, Class 2.

9-05.3(1)A End Design and Joints

All bell and spigot concrete culvert pipe shall be joined with rubber gaskets. The joints and gasket material shall meet the requirements of AASHTO M 198. Gasket material shall be handled and stored in accordance with Section 9-04.4(5).

The plane of the ends of the pipes shall be perpendicular to their longitudinal axes.

9-05.3(1)B Basis for Acceptance

The basis for acceptance of plain concrete culvert or drain pipe shall be on the results of three edge bearing tests performed at the manufacturer's plant within the 90 day period immediately preceding shipment of the pipe.

9-05.3(1)C Age at Shipment

Plain concrete culvert pipe may be shipped when it meets all test requirements. Unless it is tested and accepted at an earlier age, it shall not be considered ready for shipment sooner than 28 days after manufacture when made with Type II Portland cement, nor sooner than 7 days when made with Type III Portland cement.

9-05.3(2) Reinforced Concrete Culvert Pipe

Reinforced concrete culvert pipe shall be round and conform to the requirements of AASHTO M 170 except as herein provided.

The wall thickness and steel area for all classes of pipe which are of a diameter not set forth in AASHTO M 170, but within the maximum and minimum diameter limits set forth therein, shall be determined by interpolation from data given in the tables for pipes of diameters next smaller and next larger, respectively.

For all classes of pipe, except Class I, which are of a diameter less than the minimum for the particular class set forth in AASHTO M 170, the minimum wall thickness shall be 1³/₄-inch and the steel area shall not be less than 0.06 square inch per linear foot of pipe barrel length.

9-05.3(2)A End Design and Joints

Section 9-05.3(1)A will apply to reinforced concrete culvert pipe.

9-05.3(2)B Basis for Acceptance

The basis for acceptance of reinforced concrete pipe 60-inches in diameter and smaller shall be determined by the results of the three edge bearing test for the load to produce a 0.01-inch crack, and testing to the ultimate load will ordinarily not be required, except as necessary to obtain samples for making the absorption test. In lieu of broken pieces of pipe obtained as above provided, 4-inch diameter cores from pipe sections selected by the Engineer may be furnished for performing the absorption test. Sections of pipe which have been tested to the actual 0.01-inch crack will ordinarily not be further load tested; and such sections which meet or exceed the required strength and workmanship standards may be accepted for use on the project.

Acceptance of reinforced concrete pipe larger than 60-inches in diameter shall be based on inspection of the size and placement of the reinforcing steel, and, at the option of the Engineer, on compressive strength tests of 4-inch diameter cores cut from the pipe, or on compressive strength of representative test cylinders cast with and cured with the pipe.

9-05.3(2)C Age at Shipment

Reinforced concrete culvert pipe may be shipped when it meets the requirements of Section 9-05.3(1)C.

9-05.3(2)D Elliptical Reinforcement

In lieu of marking circular pipe with elliptical reinforcement in accordance with AASHTO M 170, the location of the top of the pipe shall be indicated by 3-inch, waterproof, painted stripes on the inside and outside of the pipe for a distance of 2-feet from each end of the section. At the option of the Contractor, a lift hole or lift holes may be provided at the top of the pipe in lieu of the painted stripes. If one lift hole is provided, it shall be at the balance point of the pipe; and if two lift holes are provided, they shall be spaced equidistant each side of the balance point. Such holes shall not interfere with the reinforcement. After placing, open lift holes shall be filled with mortar or concrete plugs before backfilling.

In addition to the requirements as set forth in AASHTO M 170, it will be required on all pipe 30-inches and over in diameter with elliptical steel reinforcement that the manufacturer expose the reinforcement in not less than one of three lengths of pipe manufactured. A hole exposing the steel shall be cut on the inside of the pipe at top or bottom and a second hole on the outside, 90 degrees from the top or bottom position. After placing, holes exposing the reinforcement shall be filled with mortar or concrete plugs before backfilling.

9-05.3(3) Beveled Concrete End Sections

Beveled concrete end sections shall be plain concrete conforming to AASHTO M 86 or reinforced concrete conforming to the applicable sections of AASHTO M 170 with the design requirements as listed in Table 2, Wall B, Circular Reinforcement in circular pipe, and the Standard Plan.

9-05.4 Steel Culvert Pipe and Pipe Arch

Steel culvert pipe and pipe arch shall meet the fabrication requirements of AASHTO M 36, Type I and Type II. Zinc coated steel shall meet the material requirements of AASHTO M 218 (ASTM A929). Aluminum coated steel shall meet the material requirements of AASHTO M-274 (ASTM A929).

9-05.4(1) Elliptical Fabrication

When elongated pipes are specified, circular pipes shall be fabricated 5 percent out of round to form an elliptical section. The vertical or longer axis of the elliptical section shall be clearly marked before shipping.

9-05.4(2) Mitered Ends

The ends of steel culvert pipe or pipe arch shall not be beveled unless called for in the plans. If beveled ends are specified, the ends of culvert pipe over 30-inches in diameter shall be mitered to conform to the slope of the embankment in which the culvert is to be placed whether the culvert is constructed normal to or at an angle with the centerline of the roadway.

Beveled steel pipe end sections 12-inches through 30-inches in diameter shall be of the same material and thickness and have the same protective coating as the pipe to which they are attached. Beveled pipe ends of these dimensions shall be constructed in conformance with the Standard Plan.

9-05.4(3) Protective Treatment

Steel pipe and pipe arch culverts shall be coated by one of the following protective treatments, when such treatment is specified:

- Treatment 1 Coated uniformly inside and out with asphalt as per 9-05.4(4) (AASHTO M190 Type A) or with polymer as per 9-05.4(5).
- Treatment 2 Coated uniformly inside and out with asphalt and with an asphalt paved invert (AASHTO M 190 Type C) or with polymer as per 9-05.4(5).
- Treatment 3 This treatment is no longer available.
- Treatment 4 This treatment is no longer available.
- Treatment 5 Coated inside and out with asphalt and a 100 percent periphery inside spun asphalt lining (AASHTO M 190 Type D).
- Treatment 6 This treatment is no longer available.

9-05.4(4) Asphalt Coatings and Paved Inverts

Asphalt for asphalt coatings and paved inverts shall meet the requirements of AASHTO M 190, Section 4. The coatings for Treatments 1, 2, and 5 shall be uniform, inside and out, and applied in accordance with the following requirements:

The metal shall be free from grease, dirt, dust, moisture, or other deleterious contaminants. Either process described below may be used for application.

1. **Pipe Not Preheated.** The temperature of the asphalt at the time of pipe immersion shall be 400°F (plus or minus 3 degrees), and the duration of the immersion shall conform to the following schedule:

Thickness in inches Steel	Minimum Immersion Time Minutes
0.064	2.5
0.079	3.0
0.109	5.0
0.138	6.5
0.168	8.0

2. **Pipe Preheated.** The asphalt shall have a temperature of 380°F (plus or minus 3 degrees), and the pipe shall be brought to a temperature of 300°F to 350°F before immersion.

The paved invert for Treatment 2 shall consist of bituminous material applied in such a manner that one or more smooth pavements will be formed in the invert filling the corrugations for at least 40 percent of the circumference.

The pavement shall have a minimum thickness of 1/8-inch above the crest of the corrugations except where the upper edges intercept the corrugation. The pavements shall be applied following the coating with asphalt. Treatment 5 may be substituted for Treatment 2, at the option of the Contractor.

9-05.4(5) Polymer Protective Coating

Polymer coated steel pipe and pipe-arch shall meet the fabrication requirements of AASHTO M 36 (ASTM A760). Polymer protective coatings shall meet the material requirements of AASHTO M 246 (ASTM A742). Polymer coating shall be mill applied to galvanized steel coils before fabrication and shall measure 10 mils thick on each side.

9-05.4(6) Spun Asphalt Lining

Asphalt for spun linings over 100 percent periphery shall conform to AASHTO M 190, Section 4. Asphalt spun linings shall provide a smooth surface for the full interior of the pipe by completely filling the corrugations to a minimum thickness of $\frac{1}{8}$ -inch above the crests. The interior lining shall be applied by centrifugal or other approved methods. The interior shall be free from sags or runs, but slight residual corrugations due to cooling shrinkage of the lining will not be cause for rejection. At the three sheet laps, an interior nonuniformity equal to the thickness of the sheet is allowable. The thickness of the lining shall be maintained to the ends of the pipe.

The thickness of the lining over the crest of the corrugation shall not vary by an amount in excess of $\frac{1}{2}$ -inch over the entire area of the spun lining.

In the case of helical corrugated pipe manufactured with a continuous lock seam, an interior nonuniformity over the lock seam equal to the thickness of two culvert sheets is allowable.

9-05.4(7) Coupling Bands

Coupling bands for steel pipe shall be as shown in the Standard Plans and shall be fabricated of the same material as the pipe. Bands may be up to three nominal thicknesses thinner than used for the pipe, but not thinner than 0.064-inches or thicker than 0.109-inches. Bands shall be coated with the same metallic protective treatment as the pipe but shall not be coated with any asphalt protective treatment. Bands shall be made by the same manufacturer as the steel pipe selected for installation.

Corrugations on the bands shall be the same size and shape as those on the pipes to be connected. Steel bolts and nuts for coupling bands shall meet the requirements of ASTM A 307 and shall be galvanized in accordance with AASHTO M 232. Steel angles, when required for coupling bands, shall meet the requirements of AASHTO M 36. When annular corrugated bands are used to connect helically corrugated lock-seam pipe, the seam shall be welded at the pipe ends prior to recorruagating to prevent unraveling of the seam. All welds shall develop the full strength of the parent metal.

Bands shall conform to the corrugations of the pipe and shall meet all applicable requirements of AASHTO M 36, with the following exceptions:

Coupling bands for all sizes of steel pipe arch with 3-inch by 1-inch corrugations shall be 24-inches wide.

Type K coupling bands shall only be used on circular culvert pipe when extending an existing culvert. Rubber gaskets shall be used and shall conform to the requirements of Section 9-04.4(3), match the width of the band, and have a minimum thickness of 1-inch.

Type K coupling bands are allowed for use on all sizes of steel pipe arch with 3-inch by 1-inch corrugations. Type K bands for this application shall be 24-inches wide. Rubber gaskets shall be used and shall conform to the requirements of Section 9-04.4(3), match the width of the band, and have a minimum thickness of 1-inch. When Type K bands are used, pipe arch ends are not required to be recorruagated.

Gaskets are required for all culvert installations and shall meet the requirements of 9-05.10(1).

9-05.4(8) Steel Nestable Pipe

Steel nestable pipe shall meet the requirements for steel pipe of these Specifications except in the method of fabrication. Circular pipe shall be fabricated in two semicircles.

Nestable pipe may be either the stitch-type as hereinafter described or the flange-type in accordance with Military Designation MIL-P-236. One longitudinal edge of each half of the stitch-type nestable circular pipe shall be notched to provide interlocking seams which will form the two segments into the full section when it is erected in the field. Hook and eye bolts, or other approved means, shall be provided to hold the segments firmly together.

Individual plates shall be a minimum of 2-feet in length except for short or half sections required to complete the end section of the culvert.

When protective treatment is specified in the Plans, nestable pipe shall be coated with one of the treatments as provided in Section 9-05.4(3).

9-05.4(9) Steel End Sections

The applicable provisions of AASHTO M 36 shall apply to the construction of steel end sections, except that the end sections shall be fabricated of the same material with the same metallic protective treatment as the pipe.

Asphalt coating shall not be used on steel end sections.

9-05.4(9)A Fabrication

The shape, thickness, dimensions, and number of pieces shall conform to the Standard Plan for the size and shape of pipe shown in the Plans. They shall be manufactured as integral units or so formed that they can be readily assembled and erected in place. When bolts are used for assembly, they shall be $\frac{3}{8}$ -inch diameter or larger and shall be galvanized. No field welding or riveting will be permitted.

9-05.4(9)B Galvanized Hardware

Bolts, nuts, and miscellaneous hardware shall be galvanized in accordance with the provisions of AASHTO M 232.

9-05.4(9)C Toe Plate Extensions

Toe plate extensions shall be furnished only when so designated in the Plans. When required, the toe plate extensions shall be punched with holes to match those in the lip of the skirt and fastened with $\frac{3}{8}$ -inch or larger galvanized nuts and bolts. Toe plate extensions shall be the same material and thickness as the end section and shall be fabricated of the same material with the same metallic protective treatment as the end section.

9-05.5 Aluminum Culvert Pipe

Aluminum culvert pipe shall conform to the applicable requirements of AASHTO M 196M.

9-05.5(1) Elliptical Fabrication

Section 9-05.4(1) shall apply to aluminum pipes.

9-05.5(2) Mitered Ends

Section 9-05.4(2) shall apply to aluminum pipes.

9-05.5(3) Vacant**9-05.5(4) Vacant****9-05.5(5) Coupling Bands**

Bands shall be fabricated of the same material as the pipe and shall meet all applicable requirements of AASHTO M 196, except the band thickness shall not be more than 0.105-inches or less than 0.060-inches. All other requirements of Section 9-05.4(7) shall apply.

9-05.5(6) Aluminum End Sections

The applicable provisions of AASHTO M 196 shall apply to the construction of end sections and toe plate extensions for aluminum pipes. In addition, they shall conform to the requirements of Section 9-05.4(9).

Asphalt coating shall not be used on aluminum end sections.

9-05.6 Structural Plate Pipe, Pipe Arch, Arch, and Underpass**9-05.6(1) General**

Structural plate pipes shall be full circle of the type, gage or thickness, and diameter specified.

Structural plate pipe arches shall be a multi-centered shape, made up of four circular arcs tangent to each other at their junctions and symmetrical about the vertical axis, and of the type, gage or thickness, and span specified.

Structural plate arches shall be a single-centered circular arc shape placed on a reinforced concrete foundation, and of the design, type, gage or thickness, and span as provided for in the Plans.

Structural plate underpasses shall be a multi-centered shape, made up of a variable number of circular arcs tangent to each other at their junctions and symmetrical about the vertical axis, and of the design, type, gage or thickness, and span specified.

9-05.6(2) Fabrication

The plates at longitudinal and circumferential seams shall be connected by bolts; the bolt holes shall be staggered in rows 2-inches apart, one hole being punched in the valley and one in the crest of each corrugation along both edges of each plate. Bolt holes on circumferential seams shall be spaced at approximate 12-inch intervals. No hole shall be closer to the edge of the plate than twice the diameter of the bolt.

The ends of structural plate pipes, pipe arches, arches, or underpasses shall not be mitered unless called for in the Plans, Special Provisions, or Standard Plan. If mitered ends are specified, the slope shall conform to the slope of the embankment in which the culvert is to be placed. The miter on pipe arches shall be limited to the top arc only.

9-05.6(3) Elliptical Fabrication

When elongated structural plate pipes are specified, they shall be fabricated 5 percent out of round to form an elliptical cross-section. The vertical axis (the longer axis of the elliptical section) shall be clearly marked on the plates before shipping.

9-05.6(4) Structural Plate Pipe Arch

Plates for structural plate pipe arches shall be formed so that the top shall be an arc of not more than 180 degrees nor less than 155 degrees; the bottom shall be an arc of not more than 50 degrees nor less than 10 degrees; and the top shall be joined at each end to the bottom by an arc having a radius between 18-inches and 31-inches and of not more than 87½ degrees nor less than 75 degrees.

9-05.6(5) Structural Plate Arch

Structural plate arches and their foundations shall be as shown in the Plans.

9-05.6(6) Structural Plate Underpass

Structural plate underpasses shall be as provided for in the Standard Plans, or, in the case of a special design, as provided for in the Plans.

9-05.6(7) Concrete

Concrete required for constructing structural plate arch foundations shall be Class 3000 concrete in conformance with the requirements of Section 6-02.

Steel reinforcing bars shall conform to the requirements of Section 9-07.1.

9-05.6(8) Plates**9-05.6(8)A Corrugated Steel Plates**

Galvanized corrugated steel plates for constructing structural plate pipe, pipe arches, arches, and underpasses, and nuts and bolts used in their assembly shall conform to the requirements of AASHTO M 167 except that the minimum mass of spelter coating on the plates shall be 3 ounces of zinc per square foot of double exposed surface. If the average spelter coating as determined from the required samples is less than 3 ounces, or if any one specimen shows less than 2.7 ounces, the lot samples shall be rejected. Nuts, bolts, and miscellaneous hardware shall be galvanized in accordance with AASHTO M 232.

9-05.6(8)B Corrugated Aluminum Plates

Aluminum alloy plates and fasteners intended for use in the construction of structural plate pipe, pipe arches, arches, and underpasses shall conform to the requirements of AASHTO M 219. Nuts, bolts, and miscellaneous hardware shall be galvanized in accordance with AASHTO M 232.

9-05.7 Concrete Storm Sewer Pipe**9-05.7(1) Plain Concrete Storm Sewer Pipe**

Plain concrete storm sewer pipe shall conform to the requirements of AASHTO M 86, Class 2.

9-05.7(1)A Basis for Acceptance

The basis for acceptance of plain concrete storm sewer pipe shall be the same as specified in Section 9-05.3(1)B.

9-05.7(2) Reinforced Concrete Storm Sewer Pipe

Reinforced concrete storm sewer pipe shall conform to the requirements of AASHTO M 170 and shall be of the class noted in the Plans or in the Special Provisions. Section 7.3.1 of AASHTO M 170 shall be amended to require that both bells and spigots shall be reinforced in pipe 30-inches in diameter and greater.

The identification of the minor axis of elliptical reinforcement shall be in accordance with Section 9-05.3(2)D.

9-05.7(2)A Basis for Acceptance

The basis for acceptance of reinforced concrete storm sewer pipe shall be the same as specified in Section 9-05.3(2)B.

9-05.7(3) Concrete Storm Sewer Pipe Joints

All concrete storm sewer pipe shall be joined with rubber gaskets. The joints and gasket material shall meet the requirements of AASHTO M 198. Gasket material shall be handled and stored in accordance with Section 9-04.4(5).

9-05.7(4) Testing Concrete Storm Sewer Pipe Joints

When a particular type of pipe joint design, material or joining method has not previously been tested and approved, the following test shall be made on one test length of the assembled storm sewer pipe to qualify the design, material or method of joining the pipe. At the option of the Engineer, additional testing may be requested if subsequent field testing of installed pipe indicates difficulty in obtaining properly joined pipe. The tests will be conducted at the manufacturer's yard, and the manufacturer will be required to make such space and facilities available as required to conduct the tests in an efficient and workmanlike manner.

9-05.7(4)A Hydrostatic Pressure on Pipes in Straight Alignment

Hydrostatic pressure tests on pipes in straight alignment shall be made in accordance with the procedure outlined in paragraph 8(a) of AASHTO M 198, except that they shall be performed on an assembly consisting of not less than three nor more than five pipe sections selected from stock by the Engineer and assembled in accordance with standard installation instructions issued by the manufacturer. The end sections shall be bulkheaded and restrained against internal pressure.

9-05.7(4)B Hydrostatic Pressure Tests on Pipes in Maximum Deflected Position

Upon completion of the test for pipe in straight alignment, the test section shall be deflected until at least two of the joints have been deflected to the maximum amount shown in the manufacturer's standard installation instructions. When thus deflected, there shall be no leakage at the joints from an applied internal hydrostatic pressure of 5 psi.

9-05.7(4)C Hydrostatic Pressure Test on 15-inch Diameter and Larger Pipe Under Differential Load

The test sections shall be suitably supported so that one of the pipes of the test assembly is suspended freely between adjacent pipes, bearing only on the joints. The suspended pipe shall then be loaded, at its midpoint, in addition to the mass of the pipe, in accordance with the following schedule:

Diameter	Load
15-inches	7,400 lbs.
18-inches	8,800 lbs.
21-inches	10,000 lbs.
24-inches and over	11,000 lbs.

While under this load, the stressed joints shall show no leakage when subjected to an internal hydrostatic pressure of 5 psi. At the option of the manufacturer, $\frac{1}{2}$ of the load may be applied on the bell end of the suspended pipe in lieu of the full load on the center of the suspended pipe.

9-05.8 Vitrified Clay Sewer Pipe

This material shall not be used in Washington State Department of Transportation projects unless specified in the Special Provisions.

Vitrified clay sewer pipe shall conform to ASTM C 700, and all joints shall be factory manufactured in accordance with ASTM C 425.

9-05.9 Steel Spiral Rib Storm Sewer Pipe

Steel spiral rib storm sewer pipe shall meet the fabrication requirements of AASHTO M 36 and these Specifications. Zinc coated steel shall meet the material requirements of AASHTO M 218 (ASTM A929). Aluminum coated steel shall meet the material requirements of AASHTO M-274 (ASTM A929). The size, coating, metal, and protective treatment, if any, shall be as shown in the Plans or in the Specifications.

The manufacturer of spiral rib storm sewer pipe shall furnish the Engineer a Manufacturer's Certificate of Compliance stating that the materials furnished comply in all respects with these Specifications. The Engineer may require additional information or tests to be performed by the Contractor at no expense to the Contracting Agency.

Unless otherwise specified, spiral rib storm sewer pipe shall be furnished with pipe ends cut perpendicular to the longitudinal axis of the pipe. Pipe ends shall be cut evenly. Spiral rib pipe shall be fabricated by using a continuous helical lock seam.

Spiral rib storm sewer pipe shall have helical ribs that project outwardly, be formed from a single thickness of material, and conform to one of the following configurations:

1. $\frac{3}{4}$ -inch wide by $\frac{3}{4}$ inch deep ribs at 7 $\frac{1}{2}$ -inches on center.
2. $\frac{3}{4}$ -inch wide by 1-inch deep ribs at 11 $\frac{1}{2}$ -inches on center.
3. $\frac{3}{4}$ -inch wide by $\frac{5}{8}$ -inch deep ribs at 12-inches on center.

Pipe shall be fabricated with ends that can be effectively jointed with coupling bands. When it is required, spiral rib pipe shall be furnished with bituminous or polymer protective treatment 1 or 2 treated or paved. The bituminous treatment for spiral rib pipe shall conform to the requirements of Sections 9-05.4(3) and 9-05.4(4). Polymer coating shall conform to Section 9-05.4(5).

9-05.9(1) Continuous Lock Seam Pipe

Pipes fabricated with a continuous helical seam parallel to the rib may be used for full circle pipe. The seam shall be formed in the flat between ribs and shall conform to Sections 7.5.1 through 7.5.3 of AASHTO M 36.

9-05.9(1)A Basis for Acceptance

The basis for acceptance will be a qualification test, conducted by the State Materials Laboratory, for each manufacturer of spiral rib lock seam steel pipe. Only those specific pipe sizes and gasket materials, if any, approved under the qualification test will be accepted.

Continuous lock seam pipe shall be sampled and tested in accordance with AASHTO T 249.

9-05.9(2) Vacant**9-05.9(3) Coupling Bands**

Coupling bands shall be of the same material as the pipe. Coupling bands and gaskets shall conform to Section 9-05.10(1).

9-05.10 Steel Storm Sewer Pipe

Steel storm sewer pipe shall conform to the requirements of Section 9-05.4 for steel culvert pipe, except that protective coating shall be Treatment 1 or 5, and be constructed of helically corrugated lock seam pipe. When gasketed helically corrugated lock seam steel pipe is called for, and the pipe is properly sized to meet hydraulic requirements, Treatment 5 is not required.

9-05.10(1) Coupling Bands

Coupling bands shall be as shown in the Standard Plans. Bands shall be fabricated of the same material as the pipe and shall meet all applicable requirements of AASHTO M 36. Bands may be up to three nominal thicknesses thinner than used for the pipe, but not thinner than 0.064-inches or thicker than 0.109-inches. Bands shall be coated with the same metallic protective treatment as the pipe but shall not be coated with any asphalt treatment. Bands shall be made by the same manufacturer as the steel pipe selected for installation.

Corrugations on the bands shall be the same size and shape as those on the pipe to be connected. Steel bolts and nuts for coupling bands shall meet the requirements of ASTM A 307 and shall be galvanized in accordance with AASHTO M 232. Steel angles, when required for coupling bands, shall meet the requirements of AASHTO M 36. When annular corrugated bands are used to connect helically corrugated lock-seam pipe, the seam shall be welded at the pipe ends prior to recorrugating to prevent unraveling of the seam. All welds shall develop the full strength of the parent metal.

Gaskets are required for all storm sewer installations. Gasket material for coupling bands shall meet the requirements of Section 9-04.4(3). Gaskets for Type D bands shall match the width of the band and have a minimum thickness of $\frac{3}{8}$ -inch. O-ring gaskets for Type F bands shall have a cross-sectional diameter of $\frac{13}{16}$ -inch for pipe diameters of 36-inches or smaller and $\frac{7}{8}$ -inch for larger pipe diameters.

Type K coupling bands are not allowed for storm sewer applications.

9-05.10(2) Basis for Acceptance

The basis for acceptance of steel storm sewer pipe will be the same as specified in Section 9-05.4, except when gasketed helically corrugated lock seam steel pipe is called for. A qualification test conducted by the State Materials Laboratory will be required for each manufacturer of gasketed helically corrugated lock seam steel pipe. Only those specific pipe sizes and gasket materials approved under the qualification test will be accepted.

9-05.11 Aluminum Storm Sewer Pipe

Aluminum storm sewer pipe shall conform to the requirements of Section 9-05.5 for aluminum culvert pipe, and the pipe shall be constructed of helically corrugated lock seam aluminum pipe.

9-05.11(1) Coupling Bands

Coupling bands for aluminum pipe shall be as shown in the Standard Plans. Bands shall be fabricated of the same material as the pipe and shall meet all applicable requirements of AASHTO M 196, except the band thickness shall not be more than 0.105-inches or less than 0.060-inches. All other requirements of Section 9-05.10(1) shall apply.

9-05.11(2) Basis for Acceptance

The basis for acceptance of aluminum storm sewer pipe will be the same as specified in Section 9-05.0, except when gasketed helically corrugated lock seam aluminum pipe is called for. A qualification test, conducted by the State Materials Laboratory, will be required for each manufacturer of gasketed helically corrugated lock seam aluminum pipe. Only those specific pipe sizes and gasket materials approved under the qualification test will be accepted.

9-05.12 Polyvinyl Chloride (PVC) Pipe**9-05.12(1) Solid Wall PVC Culvert Pipe, Solid Wall PVC Storm Sewer Pipe, and Solid Wall PVC Sanitary Sewer Pipe**

Solid wall PVC culvert pipe, solid wall PVC storm sewer pipe, and solid wall PVC sanitary sewer pipe and fittings shall be solid wall construction and shall conform to the following requirements:

For pipe sizes up to 15 inches: ASTM D 3034 SDR 35

For pipe sizes from 18 to 48 inches: ASTM F 679 using a minimum pipe stiffness of 115 psi in accordance with Table 1.

Joints for solid wall PVC pipe shall conform to ASTM D 3212 using elastomeric gaskets conforming to ASTM F 477.

Fittings for solid wall PVC pipe shall be injection molded, factory welded, or factory solvent cemented.

9-05.12(2) Profile Wall PVC Culvert Pipe, Profile Wall PVC Storm Sewer Pipe, and Profile Wall PVC Sanitary Sewer Pipe

Profile wall PVC culvert pipe and profile wall PVC storm sewer pipe shall meet the requirements of ASTM F 794 Series 46, or ASTM F 1803. Profile wall PVC sanitary sewer pipe shall meet the requirements of ASTM F 794 Series 46, or ASTM F 1803. The maximum pipe diameter shall be as specified in the Qualified Products List.

Joints for profile wall PVC culvert pipe shall conform to ASTM D 3212 using elastomeric gaskets conforming to ASTM F 477, or as approved through the State Materials Laboratory.

Qualified producers are identified in the Qualified Products List. Qualification for each producer requires joint system conformation to ASTM D 3212 using elastomeric gaskets conforming to ASTM F 477 and a formal quality control plan for each plant proposed for consideration.

A producer's Certificate of Compliance shall be required and shall accompany the materials delivered to the project. The certificate shall clearly identify production lots for all materials represented. The Contracting Agency may conduct verification tests of pipe stiffness or other properties as it deems appropriate.

Fittings for profile wall PVC pipe shall meet the requirements of ASTM F 794 Series 46, or ASTM F 1803.

9-05.13 Ductile Iron Sewer Pipe

This material shall not be used in Washington Department of Transportation projects unless specified in the Special Provisions.

Ductile iron pipe shall conform to ANSI A 21.51 or AWWA C 151 and shall be cement mortar lined, push-on joint, or mechanical joint. The ductile iron pipe shall be Class 50 or the class indicated on the Plans or in the Special Provisions.

Joints for ductile iron pipe shall be rubber gasketed conforming to the requirements of ANSI A 21.11 or AWWA C-111.

Cast iron fittings may be used with ductile iron pipe. Saddles fastened to pipe with external bands shall not be acceptable on any new system. Normally, all fittings shall be the same material as the pipe being connected, except that fittings using other materials or constructed with more than one material may be used subject to the approval of the Engineer. Fittings shall have sufficient strength to withstand handling and load stresses normally encountered.

9-05.14 ABS Composite Sewer Pipe

This material shall not be used in Washington Department of Transportation projects unless specified in the Special Provisions.

ABS composite pipe shall meet the requirements of AASHTO M 264.

ABS composite pipe shall be provided with Type OR (flexible gasketed) joints. Rubber gasketed joints shall conform to applicable provisions of ASTM C 443.

Fittings for ABS composite pipe shall be specifically designed for connection to ABS composite pipe with solvent cement. Normally, all fittings shall be the same material as the pipe being connected, except that fittings using other materials or constructed with more than one material may be used subject to the approval of the Engineer. Fittings shall have sufficient strength to withstand handling and load stresses normally encountered.

9-05.15 Metal Castings

For all metal castings the producing foundry shall provide certification stating the country of origin, the material meets the required ASTM or AASHTO Specification noted in the subsections below. The producing foundry shall detail all test results from physical testing to determine compliance to the Specifications. The test reports shall include physical properties of the material from each heat and shall include tensile, yield, and elongation as specified in the appropriate ASTM or AASHTO Specification. For AASHTO 1 M 306, Section 8, Certification is deleted and replaced with the above certification and testing requirements.

Metal castings for drainage structures shall not be dipped, painted, welded, plugged, or repaired. Porosity in metal castings for drainage structures shall be considered a workmanship defect subject to rejection by the Engineer. Metal castings made from gray iron or ductile iron shall conform to the requirements of AASHTO M 306, and metal castings made from cast steel shall conform to the requirements of Section 9-06.8. All metal castings shall meet the proof load testing requirements of AASHTO M 306.

9-05.15(1) Manhole Ring and Cover

Castings for manhole rings shall be gray iron or ductile iron and covers shall be ductile iron.

All covers shall be interchangeable within the dimensions shown in the Standard Plans. All mating surfaces shall be machine finished to ensure a nonrocking fit.

The inside vertical recessed face of the ring and the vertical outside edge of the cover shall be machined or manufactured to the following tolerances:

Ring	+3/32 inch to -3/32 inch
Cover	+3/32 inch to -3/32 inch

All manhole rings and covers shall be identified by the name or symbol of the producing foundry and country of casting origin. This identification shall be in a plainly visible location when the ring and cover are installed. Ductile iron shall be identified by the following, "DUC" or "DI." The producing foundry and material identification shall be adjacent to each other and shall be minimum ½ inch to maximum 1-inch high letters, recessed to be flush with the adjacent surfaces.

9-05.15(2) Metal Frame, Grate and Solid Metal Cover for Catch Basins or Inlets

Castings for metal frames for catch basins and inlets shall be cast steel, gray iron, or ductile iron, and as shown in the Standard Plans.

Castings for grates and solid metal covers for catch basins and inlets shall be cast steel or ductile iron and as shown in the Standard Plans. Additionally, leveling pads are allowed on grates and solid metal covers with a height not to exceed ⅛ inch. The producing foundry's name and material designation shall be embossed on the top of the grate. The material shall be identified by the following: "CS" for cast steel or "DUC" or "DI" for ductile iron and shall be located near the producing foundry's name.

Grates and covers shall be seated properly to prevent rocking, including the replacement of existing covers with solid metal covers. After seating, the frame and grate or frame and cover shall be maintained as a unit. Alternate designs are acceptable provided they conform to the manufacturer's shop drawings approved prior to Award of the Contract.

9-05.15(3) Cast Metal Inlets

The castings for cast metal inlets shall be cast steel or ductile iron, and as shown in the Standard Plans. Alternate plans are acceptable provided they conform to the fabricator's shop drawings approved prior to Award of Contract.

9-05.16 Grate Inlets and Drop Inlets

Steel in grates, angles, and anchors for grate inlets shall conform to ASTM A 36, except structural tube shall conform to ASTM A 500, Grade B, and structural shapes may conform to ASTM A 992. After fabrication, the steel shall be galvanized in accordance with AASHTO M 111, or galvanized with a hot-sprayed (plasma flame applied) 6 mil minimum thickness plasma coating.

Steel grating shall be fabricated by weld connections. Welds, welding procedures, and welding materials shall conform with the AWS D1.1/D1.1M, latest edition, Structural Welding Code.

Alternate grate designs will be permitted, with the approval of the Engineer, providing the hydraulic capacity is not decreased, the overall dimensions are the same allowing the grate to be interchangeable, and the strength is essentially equal to the grate shown in the Standard Plan or the Plans.

The Contractor has the option of furnishing either cast-in-place or precast inlets unless otherwise shown in the Plans. Alternate designs are acceptable provided they conform to the fabricator's shop drawings approved prior to Award of the Contract.

9-05.17 Aluminum Spiral Rib Storm Sewer Pipe

Aluminum spiral storm sewer pipe shall meet the fabrication requirements of AASHTO M 196 and these Specifications. Aluminum alloy shall meet the material requirements of AASHTO M 97 (ASTM B744). The size and corrugation shall be as shown in the Plans or in the Specifications. The size, metal, and protective treatment shall be as shown in the Plans or in the Specifications.

The manufacturer of spiral rib storm sewer pipe shall furnish to the Engineer a Manufacturer's Certificate of Compliance stating that the materials furnished comply in all respects with these Specifications. The Engineer may require additional information or tests to be performed by the Contractor at no expense to the Contracting Agency.

Unless otherwise specified, spiral rib storm sewer pipe shall be furnished with pipe ends cut perpendicular to the longitudinal axis of the pipe. Pipe ends shall be cut evenly. Spiral rib pipe shall be fabricated by using a continuous helical lock seam.

Spiral rib storm sewer pipe shall have helical ribs that project outwardly, be formed from a single thickness of material, and conform to one of the following configurations:

1. $\frac{3}{4}$ -inch wide by $\frac{3}{4}$ -inch deep ribs at $7\frac{1}{2}$ -inches on center.
2. $\frac{3}{4}$ -inch wide by 1-inch deep ribs at $11\frac{1}{2}$ -inches on center.
3. $\frac{3}{4}$ -inch wide by $\frac{5}{8}$ -inch deep ribs at 12-inches on center.

9-05.17(1) Continuous Lock Seam Pipe

Pipes fabricated with a continuous helical lock seam parallel to the rib may be used for full circle pipe. The lock seam shall be formed in the flat between ribs and shall conform to Sections 13.2.1 through 13.2.5 of AASHTO M 196.

9-05.17(1)A Basis for Acceptance

The basis for acceptance will be a qualification test, conducted by the State Materials Laboratory, for each manufacturer of spiral rib lock seam pipe. Only those specific pipe sizes and gasket materials, if any, approved under the qualification test, will be accepted.

Continuous lock seam pipe shall be sampled and tested in accordance with AASHTO T 249.

9-05.17(2) Coupling Bands

Coupling bands shall be of the same material as the pipe. Coupling bands and gaskets shall conform to Section 9-05.10(1).

9-05.18 Safety Bars for Culvert Pipe

Steel pipe used as safety bars and steel pipe used as sockets shall conform to ASTM A 53, Grade B. Steel tubing used as safety bars shall conform to ASTM A 500, Grade B. Steel plate shall conform to ASTM A 36. All parts shall be galvanized after fabrication in accordance with AASHTO M 111.

9-05.19 Corrugated Polyethylene Culvert Pipe

Corrugated polyethylene culvert pipe shall meet the requirements of AASHTO M 294 Type S or D for pipe 12-inch to 60-inch diameter with silt-tight joints.

Joints for corrugated polyethylene culvert pipe shall be made with either a bell/bell or bell and spigot coupling and shall incorporate the use of a gasket conforming to the requirements of ASTM D 1056, ASTM F 477, or ASTM D 5249. All gaskets shall be factory installed on the coupling or on the pipe by the producer. Qualified producers and approved joints are listed in the Qualified Products Lists.

Qualification for each producer of corrugated polyethylene culvert pipe requires an approved joint system and a formal quality control plan for each plant proposed for consideration.

A Manufacturer's Certificate of Compliance shall be required and shall accompany the materials delivered to the project. The certificate shall clearly identify production lots for all materials represented. The Contracting Agency may conduct verification tests of pipe stiffness or other properties as it deems appropriate.

9-05.20 Corrugated Polyethylene Storm Sewer Pipe

Corrugated polyethylene storm sewer pipe and fittings shall meet the requirements of AASHTO M 294 Type S or D. The maximum pipe diameter for corrugated polyethylene storm sewer pipe shall be the diameter for which a producer has submitted a qualified joint. Qualified producers are listed in the Qualified Products List. Fittings shall be blow molded, rotational molded, or factory welded.

All joints for corrugated polyethylene storm sewer pipe shall be made with a bell/bell or bell and spigot coupling and shall conform to ASTM D 3212 using elastomeric gaskets conforming to ASTM F 477. All gaskets shall be factory installed on the pipe in accordance with the producer's recommendations.

Qualification for each producer of corrugated polyethylene storm sewer pipe requires joint system conformance to ASTM D 3212 using elastomeric gaskets conforming to ASTM F 477 and a formal quality control plan for each plant proposed for consideration.

A Manufacturer's Certificate of Compliance shall be required and shall accompany the materials delivered to the project. The certificate shall clearly identify production lots for all materials represented. The Contracting Agency may conduct verification tests of pipe stiffness or other properties as it deems appropriate.